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(54) **CROSS AXIS JOINT WITH ELASTOMERIC ISOLATION**

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CPC ***F16C 11/0614*** (2013.01); ***B60G 7/005*** (2013.01); *B60G 2204/416* (2013.01)
USPC **280/124.134**; 403/132; 403/133

(58) **Field of Classification Search**
USPC 280/124.134, 124.15; 403/26, 76, 114, 403/127, 132, 133
See application file for complete search history.

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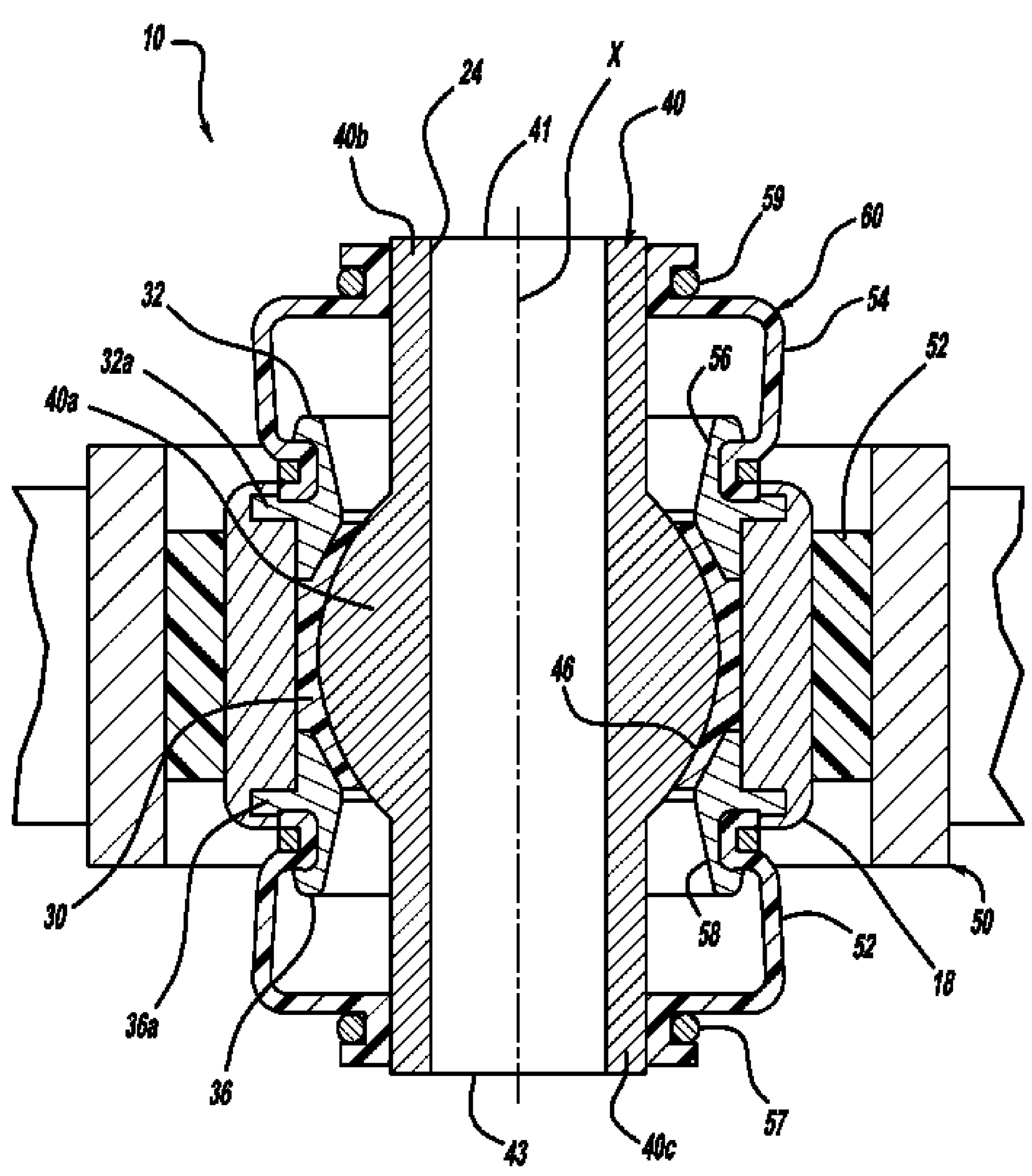
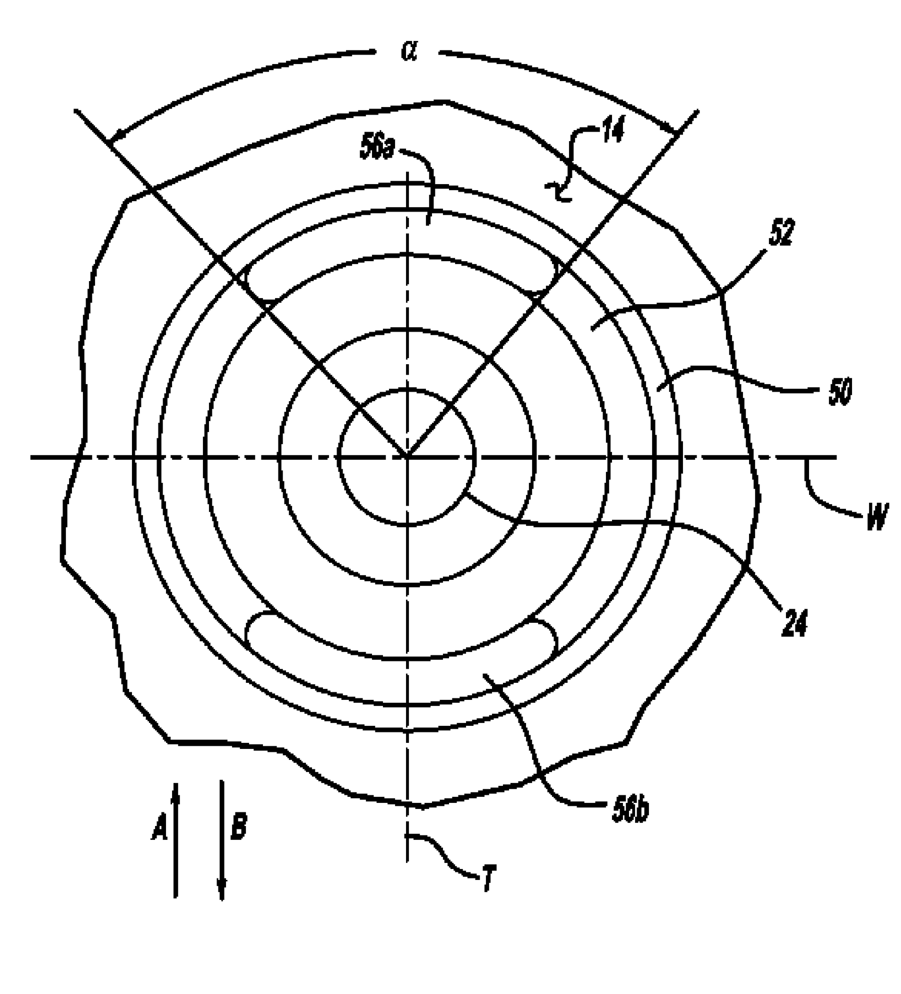
(57) **ABSTRACT**

A front lower control arm assembly includes a front lower control arm and a bushing attached to the arm. The bushing has a first central axis. A ball joint is also attached to the arm. The ball joint has a second central axis oriented substantially perpendicularly to a plane including the first central axis.

9 Claims, 3 Drawing Sheets





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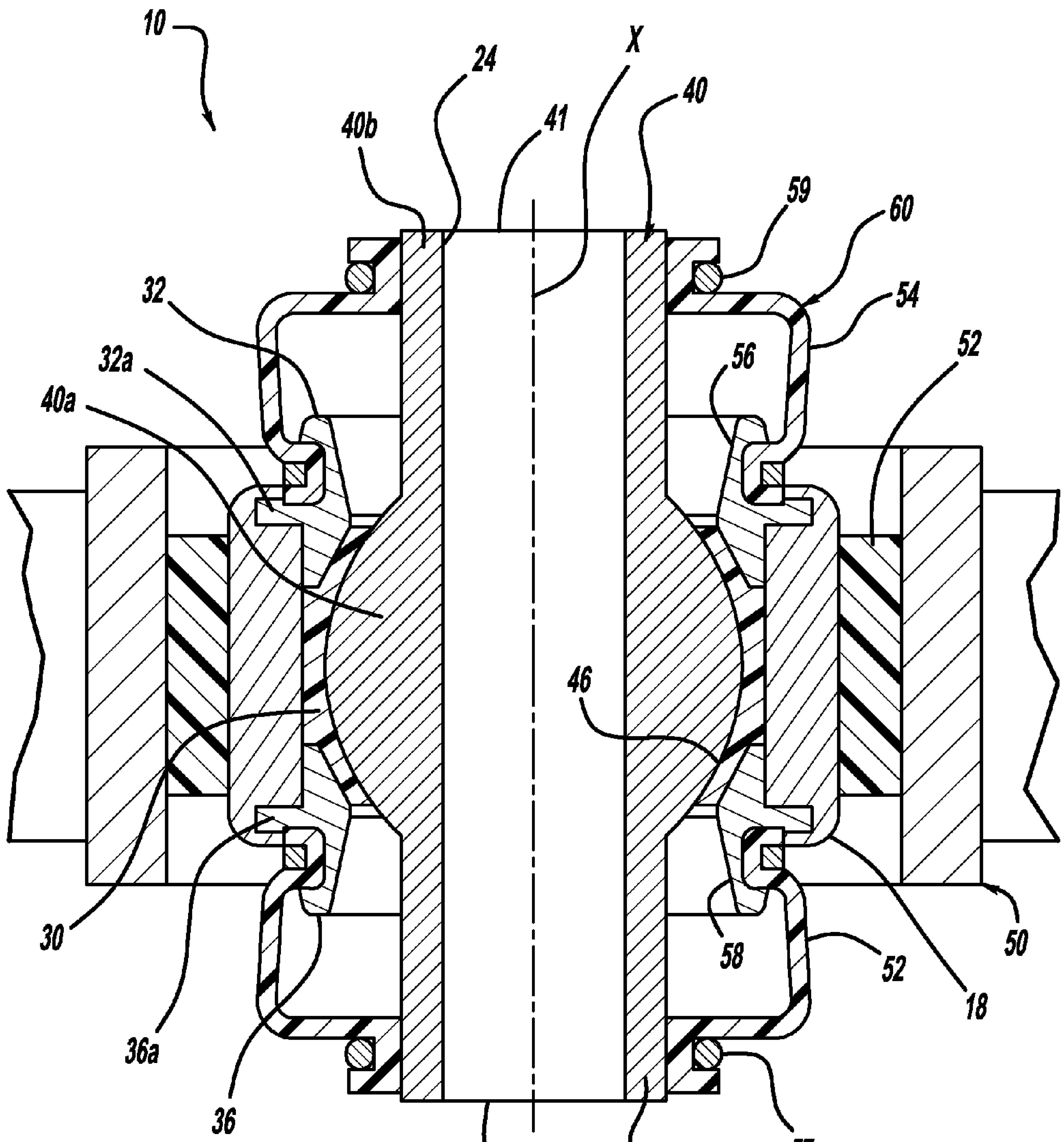
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FIG - 1

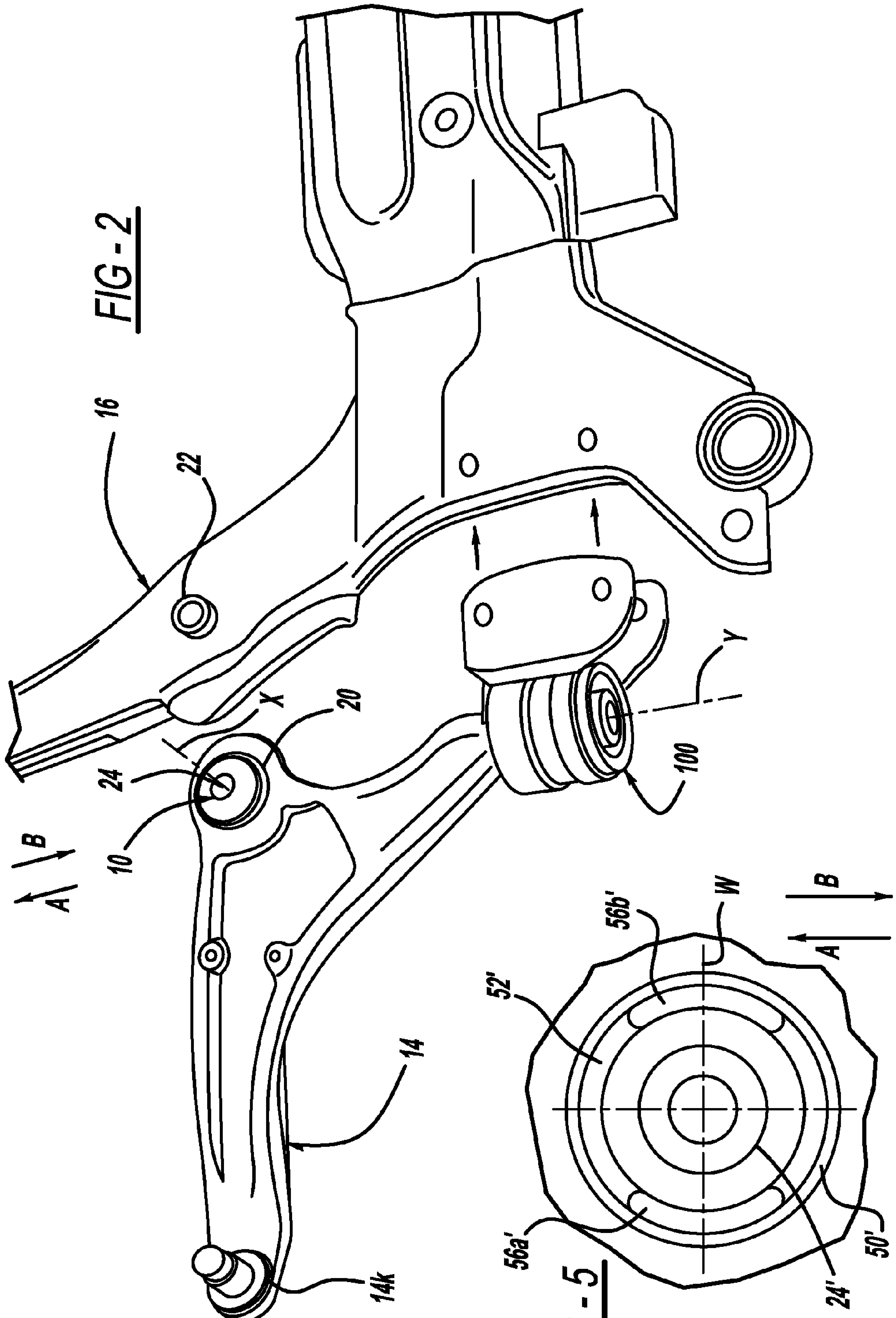

FIG - 2

FIG - 5

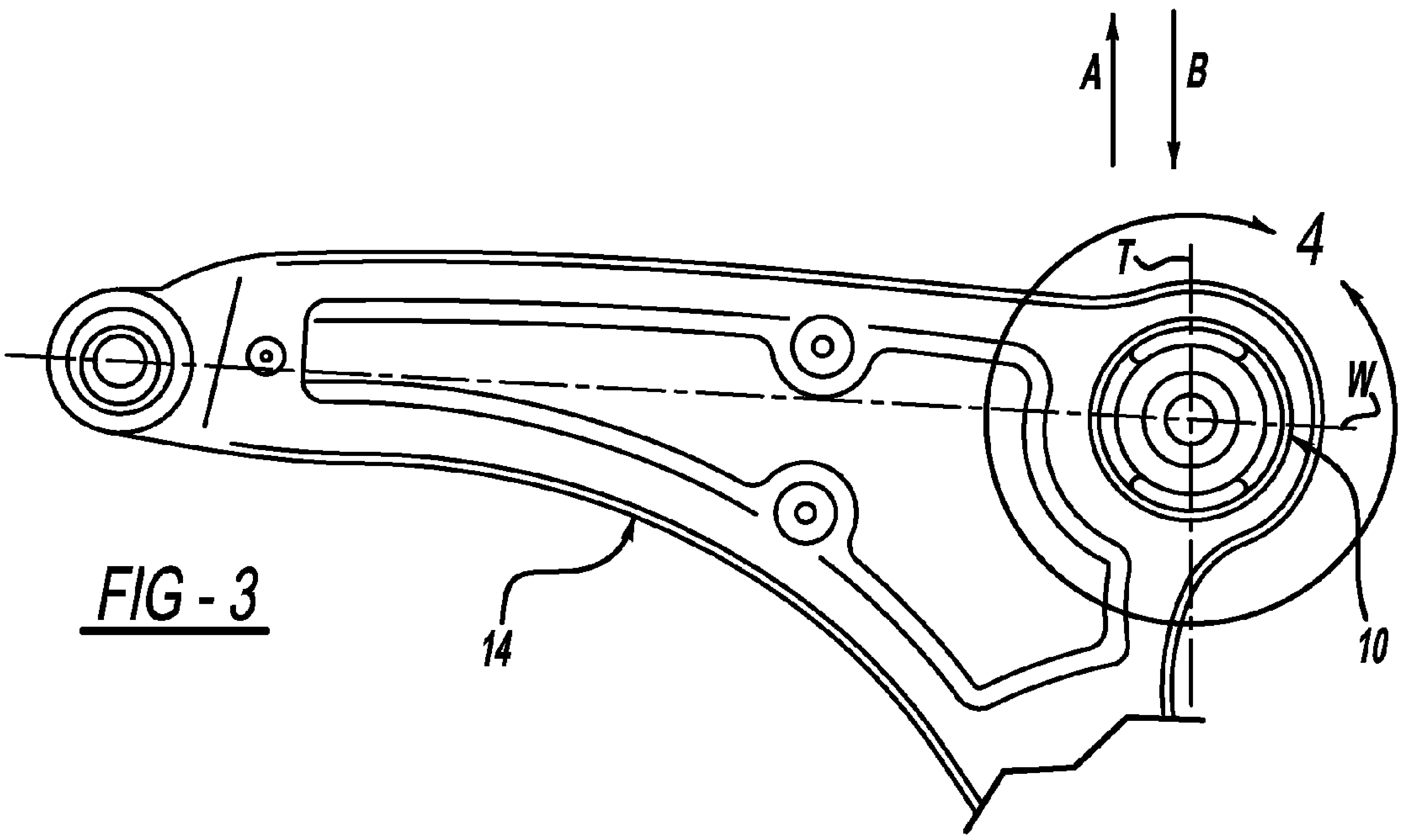

FIG - 3

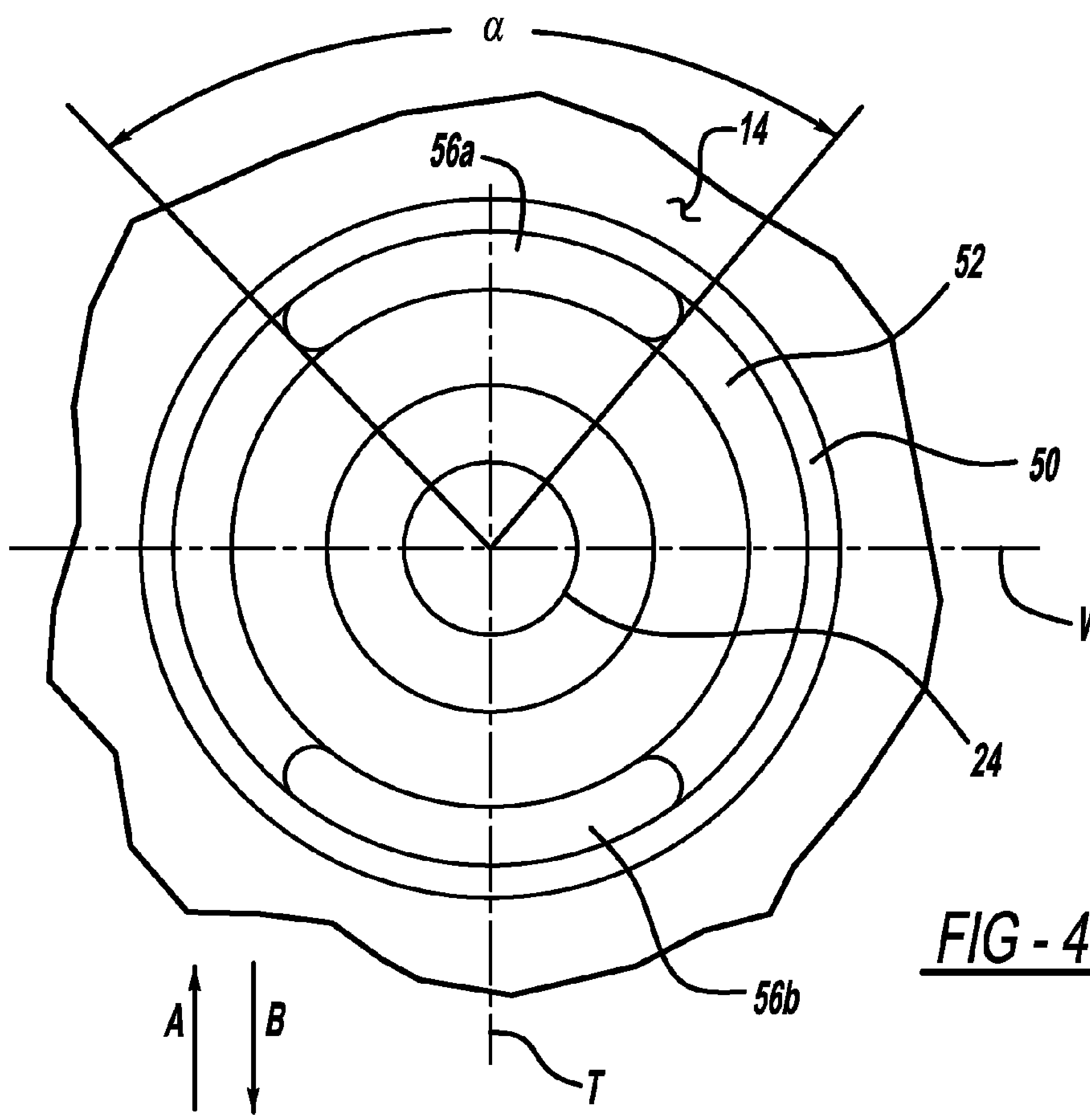

FIG - 4

CROSS AXIS JOINT WITH ELASTOMERIC ISOLATION

BACKGROUND OF THE INVENTION

The embodiments of the present invention relate to ball joints usable for connecting a lower control arm to a sub-frame of a vehicle.

SUMMARY OF THE INVENTION

In one aspect of the embodiments of the present invention, a front lower control arm assembly is provided including a front lower control arm and a bushing attached to the arm. The bushing has a first central axis. A ball joint is also attached to the arm. The ball joint has a second central axis oriented substantially perpendicularly to a plane including the first central axis.

In another aspect of the embodiments of the present invention, a vehicle is provided including a front lower control arm coupled to a vehicle sub-frame. The arm has a portion configured for attachment to a vehicle knuckle. A ball joint couples the arm to the sub-frame. The ball joint is positioned substantially laterally of the knuckle attachment portion. The joint has a central axis oriented substantially perpendicularly to an axis of rotation of the arm with respect to the sub-frame.

In another aspect of the embodiments of the present invention, a ball joint is provided including a mounting portion defining an opening therein, and a central portion positioned within the opening. An elastomeric portion is interposed between the mounting portion and the central portion to secure the central portion within the opening. At least one void is formed in the elastomeric portion.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings illustrating embodiments of the present invention:

FIG. **1** is a cross-sectional side view of a ball joint in accordance with one embodiment of the present invention.

FIG. **2** is an exploded view of a sub-assembly including a vehicle sub-frame and a front lower control arm sub-assembly incorporating a ball joint in accordance with one embodiment of the present invention.

FIG. **3** is a plan view of the lower control arm sub-assembly shown in FIG. **2**.

FIG. **4** is a magnified view of a portion of the lower control arm sub-assembly shown in FIG. **3** showing the ball joint of FIG. **1**.

FIG. **5** is a cross-sectional side view of a ball joint in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION

FIGS. **1**-**4** show a ball joint **10** and a front lower control arm sub-assembly incorporating a ball joint in accordance with one embodiment of the present invention.

In the embodiment shown in FIGS. **1**-**4**, ball joint **10** is mounted on a front lower control arm **14** of an independent suspension of a vehicle. The joint **10** is mounted substantially laterally of the portion **14***k* of the control arm at which the wheel knuckle (not shown) is attached, and connects the front lower control arm **14** to the vehicle sub-frame **16**. In the attachment position shown in FIG. **1**, joint **10** is configured so as to have a relatively high stiffness responsive to lateral loads. This enhances vehicle handling characteristics.

In this embodiment, ball joint **10** is employed as a cross axis joint designed to carry loads in a radial direction and to transfer the loads from the front lower control arm **14** to the vehicle sub-frame **16**. Ball joint **10** is secured in an opening **20** formed in the lower control arm **14**. Sub-frame **16** has an opening **22** formed therein for receiving a bolt or other suitable member (not shown) therethrough for connecting the ball joint **10** to the sub-frame. The connecting member passes through an opening **24** of the ball joint **10**. A bushing **100** or other suitable mechanism may be used to connect another portion of the front lower control arm to another portion of the sub-frame.

In the embodiment shown in FIGS. **1**-**4**, the ball joint **10** has central portion (generally designated **60**), an elastomeric portion **52**, and a mounting portion **50**. Central portion **60** may comprise (or be constructed as) a conventional ball joint or swivel joint. The following description sets forth an exemplary structure for the central portion **60** that is not intended to be limiting. However, any alternative construction of central portion **60** should be adaptable to elastomeric isolation from and within a mounting portion as described herein.

Referring to FIG. **1**, central portion **60** includes an annular housing **18**. Housing **18** may be metallic or may be formed from any suitable material. Housing **18** supports a bearing shell **30** in a cavity formed in the housing. The bearing shell **30** is secured in place within housing **18** by a first ring **32** positioned on a first side of the bearing shell and a second ring **36** positioned on a second side of the bearing shell opposite the first side. The rings **36** and **38** are held in position by deformation of the material forming the ends of housing **18**. The housing material is deformed over flanges **32***a* and **36***a* formed along respective ones of rings **32** and **36**, so as to enclose the flanges and secure the rings to the housing **18**.

A ball sleeve **40** is secured within the bearing shell **30**. Ball sleeve **40** has a generally spherical center **40***a* and a pair of projecting portions **40***b* and **40***c* extending from opposite sides of center **40***a*. Center **40***a* has a ball sleeve bearing surface **46** in contact with the bearing shell **30**. Inner through opening **24** extends through projecting portion **40***b*, center **40***a*, and projecting portion **40***c*. The ball sleeve **40** also has a first end face **41** and a second end face **43**.

As shown in FIG. **1**, the rings **32** and **36** each define a seat to receive an end of a respective sealing member **54** or **52**. Sealing member **52** has an end **56** seated in the seat formed in ring **32**. End **56** is secured in this seat by a clamping element **59**. Sealing member **52** has an end **58** seated in the seat formed in ring **36**. End **58** is secured in this seat by a clamping element **57**.

All of the components described above may be formed from any material or materials suitable for their intended uses.

In the embodiment shown in FIGS. **1**-**4**, mounting portion **50** comprises a ring radially spaced apart from housing **18**. Mounting portion **50** is used for mounting the ball joint **10** in an opening formed in front lower control arm **14**, using an interference fit or any other suitable mounting method. Mounting portion **50** may be metallic or may be formed from any suitable material.

Referring to FIGS. **1**-**4**, elastomeric portion **52** comprises an elastomeric material interposed between central portion **60** and mounting portion **50**, to provide a resilient interface between the central portion and the mounting portion. In a particular embodiment, the elastomeric material joins an outer surface **18***a* of housing **18** to an inner surface **50***a* of mounting portion **50**. Elastomeric material **52** may be a rubber compound or any other material suitable for the uses described herein. In a particular embodiment, elastomeric portion **52** comprises an elastomeric bushing seated and secured between central portion **60** and mounting portion **50**.

In the embodiment shown in FIG. **2**, a front lower control arm assembly is formed in which the ball joint **10** has a cross-axis orientation wherein the central axis X of the joint **10** is oriented substantially perpendicularly to a plane including a central axis Y of bushing **100**, rather than substantially parallel to the central axis of the bushing **100**. Central axis X is also oriented substantially perpendicularly to an axis of rotation of the front lower control arm **14** with respect to vehicle sub-frame **16** during up and down motion of a vehicle wheel (not shown) attached to the control arm. In the embodiment shown in FIG. **2**, axis X is also oriented substantially vertically or substantially perpendicular to a horizontal plane. Central axis X is also oriented substantially perpendicularly to a plane including a longitudinal or fore-aft axis of the vehicle (not shown).

Compared to a conventional bushing having an axis oriented substantially parallel to the axis of bushing **100**, the orientation of ball joint **10** shown in FIG. **2** provides a very low joint rotational rate in response to up-and-down wheel motion. This low rotational rate enhances ride quality. In addition, the elastomeric material interposed between central portion **60** and mounting portion **50** provides a relatively high lateral stiffness responsive to loading, which enhances vehicle handling characteristics. The elastomeric material also attenuates the transmission of noise, vibration, and harshness from the vehicle wheel to the vehicle frame.

The orientation of the joint central axis X described above also provides a package that is relatively compact and which can be nested in the sub-frame and attached thereto.

In a particular embodiment, gaps or voids **56***a* and **56***b* are provided in the elastomeric material **52** along opposite sides of the housing **18**. In one embodiment, the voids **56***a* and **56***b* are positioned generally along an axis T extending substantially parallel with a longitudinal or fore-aft axis of the vehicle. This positioning enables central portion **60** to shift slightly responsive to loads or load components acting along or parallel to the vehicle fore-aft axis. For example, when a force acting in the general direction indicated by arrow A (FIG. **4**) acts on ball joint **10**, void **56***a* provides less resistance to motion of central portion **60** in direction A than the elastomeric material would. Similarly, due to void **56***b*, elastomeric material that would otherwise resist motion of central portion **60** in direction A is not present. The principle just described applies equally to forces acting in the general direction of arrow B of FIG. **4**. Thus, voids **56***a* and **56***b* provide relatively lower stiffness regions which permit central portion **60** to move slightly into voids **56***a* and **56***b* toward mounting portion **50** responsive to longitudinal loading (i.e., loading acting along or substantially parallel to the vehicle fore-aft axis). As seen in FIG. **4**, each of voids **56***a* and **56***b* extends along a predetermined arc length α. In one particular embodiment, voids **56***a* and **56***b* have substantially equal arc lengths. Each of voids **56***a* and **56***b* has an arc length in the range of about 45 degrees to about 90 degrees. In a particular embodiment, voids **56***a* and **56***b* have arc lengths equal to about 60 degrees.

In one embodiment, one or more of the voids **56***a* and **56***b* extend from the mounting portion to the central portion.

It is believed that the relative stiffness and response to loading of ball joint **10** may be affected by controlling the amount of elastomeric material, the type of elastomeric material, and the arrangement of elastomeric material in the annular region between central portion **60** and mounting portion **50**. For example, if the positions of voids **56***a* and **56***b* are shifted approximately 90 degrees (as shown in FIG. **5**), voids **56***a* and **56***b* would provide relatively lower stiffness regions which permit central portion **60** to move slightly into the voids toward mounting portion **50** responsive to lateral loading (i.e., loading acting substantially perpendicular to the vehicle fore-aft axis), rather than longitudinal loading.

Also, the relative stiffness of the ball joint may be increased by reducing the void size or the arc length of the void. This has the effect of adding more elastomeric material, thus increasing the resistance to motion of central portion **60** relative to mounting portion **50**. Conversely, the relative stiffness of the ball joint may be decreased by increasing the void size or the arc length of the void. This has the effect of removing elastomeric material, thus decreasing the resistance to motion of central portion **60** relative to mounting portion **50**.

Also, the relative stiffness of the ball joint may be increased by substituting an elastomeric material having a relatively higher elastic modulus, which provides relatively greater resistance to forces acting on the central portion **60**. Conversely, the relative stiffness of the ball joint may be decreased by substituting an elastomeric material having a relatively lower elastic modulus, which provides relatively lower resistance to forces acting on the central portion **60**.

Also, the amount of elastomeric material, the type of elastomeric material, and the arrangement of elastomeric material in the annular region between central portion **60** and mounting portion **50** may be varied to affect the relative stiffness and response of the joint to up and down motion of the vehicle wheels. For example, it is believed that the positioning of elastomeric material **52** along an axis W extending from the ball joint center to the vehicle wheel (as shown in FIGS. **3** and **4**) will provide a greater relative stiffness of the ball joint responsive to up and down motion of the wheels than a distribution of elastomeric material in which voids **56***a* and **56***b* are disposed along axis W (as shown in FIG. **5**). It is also believed that varying the total amount of elastomeric material and the pertinent elastomeric material properties as previously described will affect the stiffness and response of the ball joint to up and down motion of the vehicle wheels.

In the manner described above, suitable variation of the amount of elastomeric material, the type of elastomeric material, and the arrangement of elastomeric material provides a method of "tuning" the dynamic response of the ball joint to applied loads.

It will be understood that the foregoing descriptions of various embodiments of the present invention is for illustrative purposes only. As such, the various structural and operational features herein disclosed are susceptible to a number of modifications, none of which departs from the scope of the present invention as defined in the appended claims.

What is claimed is:

1. A ball joint structure comprising:

a mounting portion defining an opening therein;

a central portion positioned within the opening;

a first quantity of elastomeric material extending uninterrupted from the mounting portion to the central portion;

a second quantity of elastomeric material extending uninterrupted from the mounting portion to the central portion;

a first void separating the first and second quantities of elastomeric material and extending uninterrupted from the mounting portion to the central portion; and

a second void separating the first and second quantities of elastomeric material and extending uninterrupted from the mounting portion to the central portion,

wherein the first void is in direct contact with both the first and second quantities of elastomeric material, and the second void is in direct contact with both the first and second quantities of elastomeric material.

2. The ball joint structure of claim **1** wherein the first and second voids are positioned on a single axis extending through a central axis of the central portion, and wherein the single axis is structured to extend substantially parallel with a fore-aft axis of a vehicle when the ball joint structure is installed in the vehicle.

3. The ball joint structure of claim **1** wherein the first void is positioned along a first side of the central portion and the second void is positioned diametrically opposite the first void along a second side of the central portion opposite the first side.

4. A vehicle including a ball joint structure in accordance with claim **1**.

5. The ball joint structure of claim **1** wherein the first void extends along an arc length of 60 degrees.

6. The ball joint structure of claim **5** wherein the second void extends along an arc length of 60 degrees.

7. A control arm assembly comprising:

a front lower control arm; and

a ball joint structure in accordance with claim **1** attached to the arm.

8. A vehicle including a control arm assembly in accordance with claim **7**.

9. The vehicle of claim **8** wherein the first and second voids are positioned on a single axis extending through a central axis of the central portion, and wherein the single axis extends substantially parallel with a fore-aft axis of the vehicle.

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